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METHOD, APPARATUS AND COMPOSITION FOR MAKING ICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method, apparatus and composition for making ice. More particularly, the invention relates to processing the floodwater that is frozen into ice, such that it forms a suitable surface for playing fast-paced sports, for example hockey.

2. Description of Related Art

Some sports, for example hockey, are best played on an ice slab that has a fast, hard, uniform surface that consistently resists rutting, chipping, cutting, sinking and sintering during use over an extended period of time. Making such a slab of ice demands much care and attention.

The best such slabs of ice are commonly frozen as laminations of ice sheets, typically including sheets less than one millimetre thick. The first sheet is created by freezing floodwater over a refrigerated floor, and thereafter each successive sheet is frozen over the previous one.

There are so many factors to monitor and control when making and maintaining a good quality ice slab that the process has developed a reputation as a bit of a black art. Quality may be affected by the number and thickness of the laminations and the time intervals between freezing the laminations. The ice slab is affected by the temperature and the humidity of the surrounding environment; if an arena is brightly lit and full of hot-blooded spectators, then the arena's refrigeration and dehumidification systems have to compensate.

The nature of the floodwater that is frozen into ice sheets is also an important factor. Conventional wisdom has maintained that the purest water freezes into the best ice. To this end, elite rinks, such as those that host the National Hockey League, employ sophisticated filtration systems to process the

available municipal water into purer floodwater. These filtration systems often include a mechanical filter, a deionization filter, and even a reverse osmosis filter.

Nevertheless, despite years of experience and access to sophisticated filtration technology, many rinks -- even elite rinks --, continue to have difficulty making and maintaining good quality ice. Accordingly, what is needed is a better way to make an ice slab that has a fast, hard, uniform surface that consistently resists rutting, chipping, cutting, sinking and sintering during use over an extended period of time.

SUMMARY OF THE INVENTION

The present invention is directed to this need.

According to one aspect of the invention, there is provided a method of processing water to create floodwater for ice-making. An additive is mixed into the water to produce floodwater having at least one of the following properties: 180 mg/L ≤ total alkalinity ($CaCO_3$) ≤ 200 mg/L, 9 mg/L ≤ hardness ($CaCO_3$) ≤ 12 mg/L, and 0 Nephelometric Turbidity Units ≤ turbidity ≤ 1 Nephelometric Turbidity Units.

The method might also include filtering the water to a commercially practical degree of purity before mixing the additive into the water, including mechanically filtering the water, deionizing the water, or reverse-osmotically filtering the water. The method might also include heating the filtered water before mixing the additive into the water.

By way of example, water filtered to a commercially practical degree of purity might be characterized by having: less than one part per million of each of aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, chromium, cobalt, copper, lead, lithium, molybdenum, nickel, phosphorus, selenium, silicon, silver, strontium, sulphur, thalium, vanadium, calcium, magnesium, manganese, sodium, potassium, chloride (Cl), sulphate (SO_4), hardness ($CaCO_3$), bicarbonate alkalinity (HCO_3), hydroxide alkalinity (CO_3), carbonate alkalinity (OH); less than five parts per million of total alkalinity (CaCO3);

a turbidity between 0 - 1 Nephelometric Turbidity Units; and a pH between 6.5 and 7.5.

Furthermore, an additive might be mixed into the water until the floodwater has at least one of the following properties: 7.5 ≤ pH ≤ 8.5, 190 mg/L ≤ bicarbonate alkalinity (HCO_3) ≤ 210 mg/L, 8 mg/L ≤ sulphate concentration (SO_4) ≤ 10 mg/L, 100 mg/L ≤ sodium concentration (Na) ≤ 130 mg/L, 3 mg/L ≤ calcium concentration (Ca) ≤ 6 mg/L, 55 mg/L ≤ chloride concentration (Cl) ≤ 70 mg/L, and 3 mg/L ≤ silicon concentration (SiO_2) between ≤ 7 mg/L.

As for the mixing additive, the additive might be a buffering salt or might more specifically be a composition comprising: 74% by mass sodium bicarbonate ($NaHCO_3$), 24% by mass sodium chloride (NaCl) and 2% by mass gypsum ($CaSO_4 \cdot 2H2O$), mixed into the water until $36x10^{-2}$ grams of the additive are present in each litre of water.

In one arrangement, the additive might be mixed into a first amount of water to create a mixture and then that mixture blended into a second amount of water.

According to another aspect of the invention, there is provided a composition of matter for mixing with water to create floodwater for making ice. The composition is such that when mixed with water it creates floodwater that has at least one of the following properties: 180 mg/L ≤ total alkalinity ($CaCO_3$) ≤ 200 mg/L, 9 mg/L ≤ hardness ($CaCO_3$) ≤ 12 mg/L, and 0 Nephelometric Turbidity Units ≤ turbidity ≤ 1 Nephelometric Turbidity Units.

The composition might be formulated to mix with water that has been filtered to a commercially practical degree of purity, and to create floodwater that has at least one of the following properties: 7.5 ≤ pH ≤ 8.5, 190 mg/L ≤ bicarbonate alkalinity (HCO_3) ≤ 210 mg/L, 8 mg/L ≤ sulphate concentration (SO_4) ≤ 10 mg/L, 100 mg/L ≤ sodium concentration (Na) ≤ 130 mg/L, 3 mg/L ≤ calcium concentration (Ca) ≤ 6 mg/L, 55 mg/L ≤ chloride concentration (Cl) ≤ 70 mg/L, and 3 mg/L ≤ silicon concentration (SiO_2) between ≤ 7 mg/L.

The composition might include a buffering salt, or more specifically might include 74% by mass sodium bicarbonate ($NaHCO_3$), 24% by mass sodium chloride (NaCl), and 2% by mass gypsum ($CaSO_4 \cdot 2H2O$).

According to another aspect of the invention, there is provided a composition of matter for making ice. This composition includes a mixture of water having a commercially practical degree of purity and 36×10^{-2} grams of an additive for each litre of water. More specifically, the additive might include might comprise 74% by mass sodium bicarbonate ($NaHCO_3$), 24% by mass sodium chloride (NaCl), and 2% by mass gypsum ($CaSO_4 \cdot 2H2O$).

According to still another aspect of the invention, there is provided another composition of matter for making ice. This composition includes water that has at least one of the following properties: 180 mg/L ≤ total alkalinity ($CaCO_3$) ≤ 200 mg/L, 9 mg/L ≤ hardness ($CaCO_3$) ≤ 12 mg/L, and 0 Nephelometric Turbidity Units ≤ turbidity ≤ 1 Nephelometric Turbidity Units.

This composition might further have one of the following properties: 7.5 ≤ pH ≤ 8.5, 190 mg/L ≤ bicarbonate alkalinity (HCO_3) ≤ 210 mg/L, 8 mg/L ≤ sulphate concentration (SO_4) ≤ 10 mg/L, 100 mg/L ≤ sodium concentration (Na) ≤ 130 mg/L, 3 mg/L ≤ calcium concentration (Ca) ≤ 6 mg/L, 55 mg/L ≤ chloride concentration (Cl) ≤ 70 mg/L, and 3 mg/L ≤ silicon concentration (SiO_2) between ≤ 7 mg/L.

This composition might further include a buffering salt and more specifically might include: 26×10^{-2} grams of sodium bicarbonate ($NaHCO_3$) for each litre of water, 84×10^{-3} grams of sodium chloride (NaCl) for each litre of water, and 96×10^{-4} grams of gypsum ($CaSO_4 \cdot 2H2O$) for each litre of water.

According to yet another aspect of the invention, there is provided an apparatus for processing water into floodwater for making ice. The apparatus includes a mixer connected to receive water having a commercially practical degree of purity and to receive an additive. The mixer is configured to mix the water and the additive to create a floodwater mixture.

The apparatus might further include a filtration stage for filtering water, connected to supply the filtered water to the mixer. This filtration stage might variously include a mechanical filter, a deionization filter, or a reverse-osmosis filter.

The apparatus might also include a heater for heating water, connected to supply the heated water to the mixer.

The apparatus might include a dispensing valve for controlling the amount of additive dispensed into the mixer for mixing with the water. A mix-tester could test a property of the mixture within the mixer, for example the mixture's: total alkalinity ($CaCO_3$), hardness ($CaCO_3$), turbidity, pH, bicarbonate alkalinity (HCO_3), sulphate concentration, sodium concentration (Na), calcium concentration (Ca), chloride concentration (Cl), or silicon concentration (SiO_2). In this arrangement, the setting of the dispensing valve could be responsive to the mix-tester.

The apparatus might also include a shunt valve for controlling the amount of water supplied to the mixer for mixing with the additive, and the setting of the shunt valve could also be responsive to the mix-tester.

The apparatus might also include a blender connected to receive water having a commercially practical degree of purity and mixture from the mixer for blending the water and the mixture to create a floodwater blend. Similar to the mixer, the blender could be connected to a mix valve for controlling the amount of mixture received by the blender for blending with the water and a main valve for controlling the amount of water received by the blender for blending with the mixture.

Furthermore, the apparatus might include a blend-tester for testing a property of the blend within the blender, for example the blend's: the mixture's: total alkalinity ($CaCO_3$), hardness ($CaCO_3$), turbidity, pH, bicarbonate alkalinity (HCO_3), sulphate concentration, sodium concentration (Na), calcium concentration (Ca), chloride concentration (Cl), or silicon concentration (SiO_2). In this arrangement, the setting of the mix valve or the main valve could be responsive to the blend-tester.

The apparatus might also include a mix flowmeter for measuring the flow of mixture into the blender or a main flowmeter for measuring the flow of filtered water into the blender. In this arrangement, the setting of the mix valve could be responsive to the mix flowmeter and the setting of the main valve could be responsive to the main flowmeter.

The apparatus might further include a control module responsive to at least one of: the mix-tester, the blend-tester, the mix flowmeter, and the main flowmeter. Furthermore, at least one of the dispensing valve, the shunt valve, the mix valve, and the main valve might be responsive to the control module. In this arrangement, the control module could control at least one of the dispensing valve, the shunt valve, the mix valve, and the main valve such that the blend has at least one of the following properties: 180 mg/L ≤ total alkalinity ($CaCO_3$) ≤ 200 mg/L, 9 mg/L ≤ hardness ($CaCO_3$) ≤ 12 mg/L, 0 Nephelometric Turbidity Units ≤ turbidity ≤ 1 Nephelometric Turbidity Units, 7.5 ≤ pH ≤ 8.5, 190 mg/L ≤ bicarbonate alkalinity (HCO_3) ≤ 210 mg/L, 8 mg/L ≤ sulphate concentration (SO_4) ≤ 10 mg/L, 100 mg/L ≤ sodium concentration (Na) ≤ 130 mg/L, 3 mg/L ≤ calcium concentration (Ca) ≤ 6 mg/L, 55 mg/L ≤ chloride concentration (Cl) ≤ 70 mg/L, and 3 mg/L ≤ silicon concentration (SiO_2) between ≤ 7 mg/L.

Further aspects and advantages of the present invention will become apparent upon considering the following drawings, description, and claims.

DESCRIPTION OF THE INVENTION

The invention will be more fully illustrated by the following detailed description of specific embodiments in conjunction with the accompanying drawing figures, in which like reference numerals designate like parts throughout the various figures.

1. Brief Description of the Drawings

Figure 1 is a schematic view of an apparatus according to one aspect of the present invention.

Figure 2 is a schematic view of the apparatus of Figure 1, detailing the connection of a control module.

2. Detailed Description of Specific Embodiments

(a) Structure

The structure of the invention will now be illustrated by way of specific exemplary embodiments shown in the drawing figures and described in greater detail herein.

Figure 1 shows a water treatment system according to one embodiment of the present invention, generally illustrated at **10**. The water treatment system **10** is connected through a shut-off valve **14** to receive a supply of water from a source **12** that is not necessarily a part of the invention, for example a municipal water utility.

The shut-off valve **14** is connected to supply a filtration stage **16**, which in this embodiment includes a mechanical filter **18**, a deionization filter **20**, and a reverse-osmosis filter **22** connected together in series. While for completeness of illustration both the deionization filter **20** and the reverse-osmosis filter **22** have been included, in commercial embodiments generally one or the other is considered sufficient.

The filtration stage **16** is connected to supply a heating tank **23**. The heating tank **23** is connected to a source of energy **Q** and has a temperature set point, which in this embodiment is set to 74 degrees Celsius. Although illustrated as a tank in this embodiment, the heating tank **23** may be any sort of heating vessel, for example a continuous in-line heater. The heating tank **23** has a bifurcated output port **24**, having both a main pipe **24a** and a shunt **24b**.

The shunt **24b** is connected to supply a mixer **26** through a shunt valve **28**. A hopper **30**, which is adapted to store and dispense an additive, is connected to also dispense the additive into the mixer **26** through a dispensing valve **32**. A mix-tester **34** is operable to test specific properties of the mixture within the mixer **26**, as will be described in greater detail below. In this regard, the mix-tester **34** may be

any well-known sensor or sensor system for testing one or more specific properties of the mixture. It should be understood that the mixture may be a mechanical mixture, a solution, or a suspension.

The water treatment system **10** further includes a blender **36**, which is connected to receive flows from both the main pipe **24a** and the mixer **26**. In this embodiment, the main pipe **24a** connects to the blender **36** through a main valve **38** and the mixer **26** connects to the blender **36** through a mix valve **40**. Additionally, the water treatment system **10** may also include a main flowmeter **44** connected inline between the main pipe **24a** and the blender **36** and a mix flowmeter **46** connected inline between the mixer **26** and the blender **36**. A blend-tester **42** is operable to test specific properties of the blend within the blender **36**, as will be described in greater detail below. In this regard, the blend-tester **42** may be any well-known sensor or sensor system for testing one or more specific properties of the blend.

The blender **36** is connected to supply the blend to a discharge line **48**, in this embodiment conveniently through a discharge valve **50**, the discharge line **48** being operable to discharge the blend onto a surface as floodwater for freezing into ice.

Figure 2 shows that portion of the water treatment system **10** that follows the filtration stage **16**, and in particular details a way to control the water treatment system **10**, in this embodiment through a control module **52**, be it electric, electronic, fluidic, hydraulic, hybrid, or otherwise. The control module **52** is connected to receive data signals encoding measurement data from the mix-tester **34**, the blend-tester **42**, the main flowmeter **44**, and the mix flowmeter **46** and to issue in response command signals to the shunt valve **28**, the dispensing valve **32**, the main valve **38** and the mix valve **40**, so as to urge the mixture in the mixer **26** and the blend in the blender **36** toward specifically desired properties as described below in greater detail.

(b) Operation

With reference to the both **Figures 1 and 2**, the operation of these specific embodiments of the invention will now be described.

Water from an external source **12** is received into the water treatment system **10** through the shut-off valve **14**. The water is passed through the filtration stage **16** such it achieves a commercially practical degree of purity. By way of example only, for this purpose it has been found that water is sufficiently pure if it:

- has less than one part per million of each of:
    - aluminum,
    - antimony,
    - arsenic,
    - barium,
    - beryllium,
    - bismuth,
    - boron,
    - cadmium,
    - chromium,
    - cobalt,
    - copper,
    - lead,
    - lithium,
    - molybdenum,
    - nickel,
    - phosphorus,
    - selenium,
    - silicon,
    - silver,
    - strontium,
    - sulphur,

  - thalium,
  - vanadium,
  - calcium,
  - magnesium,
  - manganese,
  - sodium,
  - potassium,
  - chloride (Cl),
  - sulphate (SO_4),
  - hardness ($CaCO_3$),
  - bicarbonate alkalinity (HCO_3),
  - hydroxide alkalinity (CO_3),
  - carbonate alkalinity (OH);
- has less than five parts per million of total alkalinity ($CaCO_3$);
- has a turbidity between 0 - 1 Nephelometric Turbidity Units; and
- has a pH between 6.5 and 7.5.

The purified water is supplied to the heating tank 23, where it undergoes a heating cycle to a temperature of 74 degrees Celsius.

The heated purified water is then fed into the mixer **26** through the shunt valve **28**. An additive is added to the hopper **30** and dispensed into the mixer **26** through the dispensing valve **32** for mixing with the heated purified water in the mixer **26** to form a mixture.

Heated purified water is also fed into the blender **36** through the main pipe **24a**, the main valve **38** and the main flowmeter **44** and blended therein with the mixture received from the mixer **26** through the mix valve **40** and the mix flowmeter **46**.

The blend from the blender **36** is then discharged through the discharge line **48** via the discharge valve **50** for freezing into ice.

It will be appreciated that the shunt valve **28**, the dispensing valve **32**, the main valve **38** and the mix valve **40** provide ways to control the amount of additive received from the hopper **30** that is combined with substantially pure water from the filtration stage **16** and thus ultimately the composition of the blend discharged through the discharge line **48**. It will further be appreciated that the mix-tester **34**, the blend-tester **42**, the main flowmeter **44**, and the mix flowmeter **46** provide ways to monitor these amounts for the purpose of adjusting the shunt valve **28**, the dispensing valve **32**, the main valve **38** and the mix valve **40** to control the composition of the blend discharged through the discharge line **48.** Those skilled in the art will understand that, for the purpose of illustration, more control elements (the shunt valve **28**, the dispensing valve **32**, the main valve **38** and the mix valve **40**) and monitoring elements (the mix-tester **34**, the blend-tester **42**, the main flowmeter **44**, and the mix flowmeter **46**) have been included in this embodiment than are necessary to control the composition of the blend discharged through the discharge line **48.**

Against the conventional wisdom, experimentation has shown that an ice slab having a fast, hard, uniform surface that consistently resists rutting, chipping, cutting, sinking and sintering during use over an extended period of time can be repeatably created if the floodwater being frozen has at least one of the following characteristics:

- total alkalinity ($CaCO_3$) between 180 - 200 mg/L,
- hardness ($CaCO_3$) between 9 - 12 mg/L, and
- turbidity between 0 - 1 Nephelometric Turbidity Units.

It has also been found to be secondarily desirable that the floodwater has any of the following characteristics:

- pH between 7.5 and 8.5,
- bicarbonate alkalinity (HCO_3) between 190 - 210 mg/L,
- sulphate concentration (SO_4) between 8 - 10 mg/L,

- sodium concentration (Na) between 100 - 130 mg/L,
- calcium concentration (Ca) between 3 - 6 mg/L,
- chloride concentration (Cl) between 55 - 70 mg/L, and
- silicon concentration (SiO_2) between 3 - 7 mg/L.

At least some of these characteristics can be simply obtained by mixing/blending a known quantity of substantially pure water with a known quantify of additive that will mix with and at least partially dissolve in the water to yield these characteristics. Heating the water encourages such dissolution.

For example, these characteristics have been repeatably achieved by mixing/blending 568 litres of substantially pure water with 202 grams of an additive comprising 149 grams of sodium bicarbonate ($NaHCO_3$), 48 grams of sodium chloride (NaCl), and 5 grams gypsum ($CaSO_4 \cdot 2H2O$).

Expressed more generally, it has been found that an ice slab having a fast, hard, uniform surface that consistently resists rutting, chipping, cutting, sinking and sintering during use over an extended period of time can be repeatably created if the floodwater being frozen is substantially pure water except for the fact that it includes $36x10^{-2}$ grams per litre of the additive, which corresponds to $26x10^{-2}$ grams per litre of sodium bicarbonate ($NaHCO_3$), $84x10^{-3}$ grams per litre of sodium chloride (NaCl), and $96x10^{-4}$ grams per litre of gypsum ($CaSO_4 \cdot 2H2O$).

Those skilled in the art will appreciate that other additives, for example various buffering salts, would also produce desirable results without departing from the teaching of the present invention. Those skilled in the art will also appreciate that the freezing point of a liquid is a colligative property.

Thus, it will be seen from the foregoing embodiments and examples that there has been described a way to make an ice slab that has a fast, hard, uniform surface that consistently resists rutting, chipping, cutting, sinking and sintering during use over an extended period of time.

While specific embodiments of the invention have been described and illustrated, such embodiments should be considered illustrative of the invention only and not as limiting the invention as construed in accordance with the accompanying claims. In particular, all quantities described have been determined empirically and those skilled in the art might well expect a wide range of values surrounding those described to provide similarly beneficial results.

It will be understood by those skilled in the art that various changes, modifications and substitutions can be made to the foregoing embodiments without departing from the principle and scope of the invention expressed in the claims made herein.

For example, if the water received at the shut-off valve **14** were either already of a commercially practical purity or heated to a temperature close to 74 degrees Celsius, then the filtration stage **16** or the heating tank **23** might respectively be omitted from the water treatment system **10**. To further simplify the water treatment system **10**, mixing and blending could be accomplished in a single step.

As another example, instead of implementing an automatic control module **52**, similar results could be achieved by having a technician observe the monitoring elements (mix-tester **34**, blend-tester **42**, main flowmeter **44**, mix flowmeter **46**) and set the control elements (shunt valve **28**, dispensing valve **32**, main valve **38**, mix valve **40**). Furthermore, once the water treatment system **10** was calibrated, some or all of the monitoring elements (mix-tester **34**, blend-tester **42**, main flowmeter **44**, mix flowmeter **46**) could be omitted and the control elements (shunt valve **28**, dispensing valve **32**, main valve **38**, mix valve **40**) could be fixed, such that a known amount of additive added into the hopper **30** could be mixed with a known flow of substantially purified water to produce the desired composition of floodwater at the discharge line **48**. In this latter situation for example, a technician, either on-site or off-site, could act as a blend-tester **42**, monitoring sample batches of the blend to ensure it has the desired properties and determining how to adjust the control

elements (shunt valve **28**, dispensing valve **32**, main valve **38**, mix valve **40**) should an adjustment in the properties of the blend be appropriate.

While the invention has been described as having particular application for hockey, those skilled in the art will recognize it has wider application.